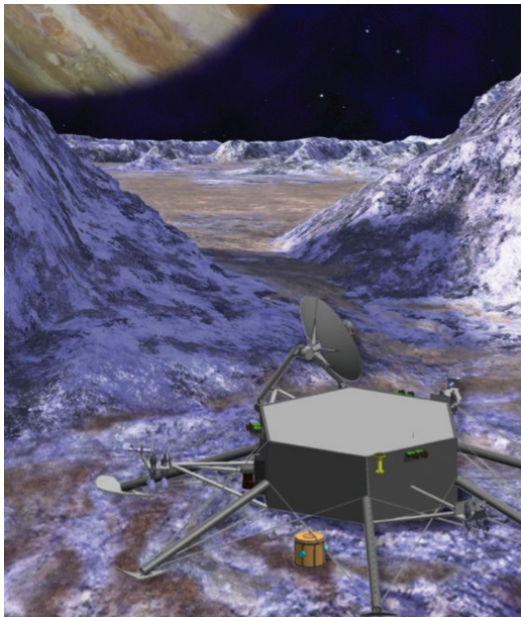


Radioisotope Power Systems: Mission Need

Radioisotope Power Systems (RPS) are long-lived sources of spacecraft electrical power and heating that are rugged, compact, highly reliable, and relatively insensitive to radiation and other effects of the space environment. This makes them an excellent option to produce power or heat for a variety of potential missions to some of the most extreme space and planetary environments in the solar system.

Many of NASA's proposed future missions aim to answer profound questions about the origin, evolution and fate of life in the solar system—does it exist beyond Earth? If so, how did it start, and how might it compare to life here? Other mission concepts would illuminate our understanding of the earliest days of the solar system, and why planets like Venus and Mars evolved so differently than Earth.

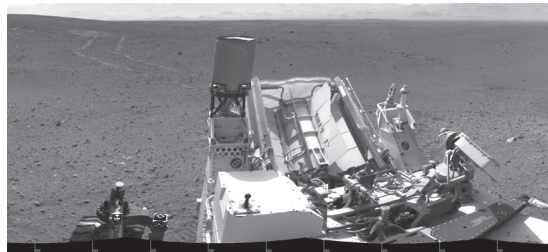


Artist's concept by Mike Carroll

A concept for an RPS-powered mission that could softly land a science station on Jupiter's large moon Europa, which may harbor a liquid water ocean beneath its icy crust.

Flown on 27 U.S. space missions over the past five decades and counting, RPS are used only when they would enable or significantly enhance the capability of a mission to accomplish its scientific or technology development goals.

All RPS missions flown so far have used Radioisotope Thermoelectric Generators (RTG), such as the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) launched in November 2011 aboard the Curiosity Mars rover. RTGs employ thermoelectric power conversion, where a temperature difference applied across the junction of two different metallic compounds is used to generate the electricity. Although designed for an operating lifetime of about 14 years, every RPS of this type that has flown in space has far surpassed this period of operation.



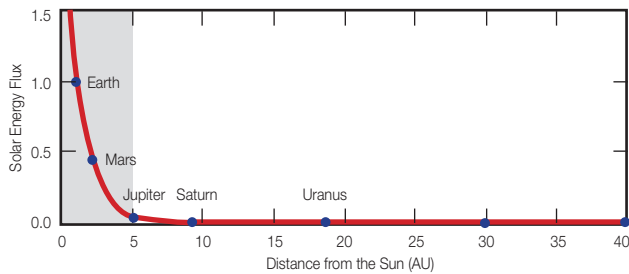
Self portrait of the Curiosity Mars rover and its RPS (the white cylinder with fins, at center) on the surface of the Red Planet in September 2012.

A new form of RPS called an Advanced Stirling Radioisotope Generator (ASRG) is currently under development. The heat from the radioisotope fuel in an ASRG is used to drive a piston that moves back and forth over 100 times per second to generate an electrical current via a linear alternator. An ASRG can produce electricity about four times more efficiently than the more traditional RPS, meaning it can use one-quarter of the radioisotope fuel to generate a comparable amount of power.

Each of the two current types of RPS has unique strengths. The MMRTG offers a significant amount of excess heat that can be used to keep spacecraft electronics and systems warm in cold environments; the Curiosity rover uses this heat to its benefit on Mars. Conversely, the ASRG produces much less heat, which can be an advantage for missions where removing that heat would be an issue. Furthermore, the ASRG is expected to be about 25 percent lighter than the MMRTG (which equates to about 26 pounds or 12 kilograms less mass). This could make the ASRG attractive for smaller spacecraft or perhaps multiple spacecraft—such as an orbiter and lander—launched together.

NASAfacts

Together, these two types of RPS serve to support a variety of future mission designs in their ability to function fully and reliably over a wide range of extreme conditions and destinations.



The energy of sunlight decreases rapidly as distance from the Sun increases.

The most common past use of RPS for planetary science has been to power spacecraft on deep space missions designed to travel where sunlight drops to a tiny fraction of its intensity at Earth's orbit. Impressive progress has been made with low-temperature, low-intensity solar cells on spacecraft such as the Juno mission on its way to Jupiter. But the unavoidable decline in the sun's energy as one moves outward in the solar system will always present significant limitations.

Long-duration missions to the high latitudes of the surface of Mars and to the surface of the Moon (which is naturally in darkness for two weeks out of every month) are also considered extremely challenging, if not impossible, for power systems using solar arrays and batteries alone.

Sunlight may also be too weak to supply enough electrical power for a given mission when it is highly intermittent, or obscured by an opaque or especially dusty planetary atmosphere.

For example, the vast distance from the sun to Saturn means that sunlight received in the neighborhood of the ringed planet is already 100 times less intense than the sunlight that reaches Earth orbit. The thick, hazy atmosphere of organic chemicals on Saturn's moon Titan absorbs another 60 percent of this already faint incoming energy. On Mars, the ever-present red dust has cut the amount of energy produced by the solar panels on the Mars Exploration Rover Opportunity in half, despite several serendipitous cleaning events from local winds and random "dust devils" that can help clean the panels.

When appropriately shielded, RPS are also generally impervious to the physical effects of dust and to the extremes in temperature that can affect almost every mission to space, where swings between intense heat and frigid cold can span 300 degrees, sometimes in a matter of seconds.

On the cold end of the spectrum, small components called Radioisotope Heater Units (RHUs)—each of which generates



A concept for an RPS-powered hot-air balloon that could explore the atmosphere of Saturn's moon Titan for several months, and perhaps analyze samples of its lakes.

about one watt of heat—can be used to keep the electronics and other internal systems in spacecraft, rovers, and landers at proper operational temperature in deep space or in long-duration shadows. More than 300 of these pencil eraser-size components have been flown on solar system exploration missions such as the Cassini mission, orbiting Saturn for more than eight years, and the Opportunity rover, helping it survive through more than a half-dozen frigid winter seasons on the red planet.

Unlike the sensitive electronic junctions in solar panels, the power-producing elements of RPS are not greatly threatened by space radiation, which can be a severe problem in environments such as the Jupiter system. This intense radiation limits the Juno spacecraft to a one-year primary mission, even with a specially customized orbit that largely avoids the gas giant planet's damaging radiation belts.

Whether it be missions to comets and asteroids, distant planetary moons, the still-mysterious outer planets Uranus and Neptune, or the vast Kuiper Belt, scientists have identified a host of amazing destinations that ambitious RPS-powered missions could uniquely explore in the years ahead, in ways that would not be possible with other power systems alone.

For more information, visit rps.nasa.gov